Ventilating Your Energy-Efficient Home

Montana Department of Natural Resources and Conservation

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Energy MATTERS

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Free from
Montana Department of Natural Resources and Conservation
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Table of Contents

Introduction

In the past, bringing fresh air indoors was not a concern. Most houses received enough fresh air by natural air leakage. Today, however, that attitude is changing. Two important trends have led to a concern about adequate ventilation:

- Since 1974, fuel prices have increased significantly. In an effort to reduce heating bills, homeowners have been reducing air leakage by adding insulation, weatherstripping doors and windows and sealing cracks in the building envelope.

- In the past five years, advances in residential construction techniques have meant that new homes are well sealed and have higher insulation levels. Also, new higher efficiency heating systems reduce air leakage by reducing chimney losses.

Air-sealing techniques and special construction methods have successfully reduced heating bills and increased comfort. However, tightly sealed homes may result in unsafe operation of combustion appliances, condensation problems, or concentrations of air contaminants that may impair health or cause discomfort.

Most tightly-built new homes in Montana are electrically heated, but it is possible to safely install combustion heating systems and appliances (wood, natural gas, propane or fuel oil) in tight homes. The Montana Department of Natural Resources and Conservation recommends that sealed combustion furnaces, wood stoves and appliances be used in tight new homes; these furnaces, wood stoves and appliances have their own direct outdoor combustion air supplies so they won't draw indoor air from the house for burning. Fireplaces should also have their own direct outdoor combustion air supplies. Chapter Six of "The Uniform Mechanical Code," which is in effect throughout Montana, covers safe installations of combustion furnaces and appliances. If you should have questions about safety, contact your local building code official or the Montana Building Codes Bureau, 1218 East Sixth Avenue, Helena, MT 59620, phone 444-3933.

Although poor air quality and inadequate ventilation are not widespread, there is now a greater potential for such problems. The purpose of this booklet is to increase your awareness of ventilation and to help you identify any potential or existing problems in your home.

These problems can be solved by carefully controlling the movement of indoor and outdoor air within the house environment. **The exchange of indoor and outdoor air is called ventilation**. The term **natural ventilation** is used to describe air exchange occurring without the use of mechanical devices. This could be through unintentional openings (such as air leakage through cracks in the home) or through intentional openings (such as operable windows or fresh air ducts). **Mechanical ventilation** refers to air exchange created by electric fans.

Attic ventilation will not be discussed in this booklet as it does not significantly affect the indoor air quality.

Understanding New Terminology

This section describes terms used in this booklet (Figure 1).

Air Change Rate

The rate at which air inside the house is replaced by outside air through a combination of natural and mechanical ventilation. For example, an air change rate of one-half air change per hour (ACH) means that half the volume of air in the house is exhausted and replaced by fresh air each hour.

Circulation Air

Indoor air that is moved around the house by a circulating fan as in forced air heating systems.

Combustion Air

The air required to ensure efficient and safe operation of combustion appliances such as fuel-fired furnaces, water heaters and fireplaces.

Dilution Air

The air required by some combustion heating systems to safeguard the heater from pressure fluctuations in the flue and to maintain an effective chimney draft.

Exhaust Air

Air expelled outdoors by bathroom and kitchen fans, clothes dryers, power vacuums, etc.

Exfiltration

The uncontrolled leakage of indoor air out of the house through cracks around windows, doors, electrical outlets and through other openings such as the chimney.

Infiltration

The uncontrolled leakage of outdoor air into the house through cracks around windows, doors, electrical outlets and other openings.

Replacement Air

Outdoor air that replaces the air removed from the house by dilution air, exhaust air and exfiltration. It is usually supplied by fresh air inlets intentionally installed in the home or by infiltration.

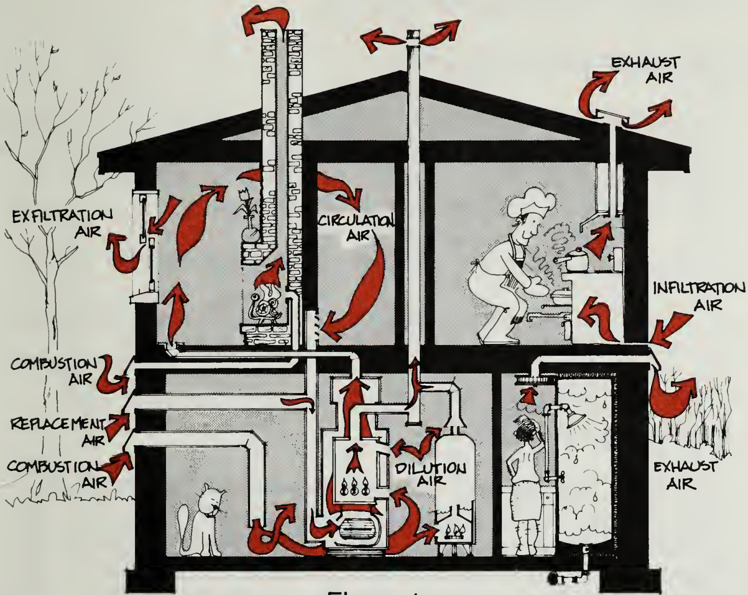


Figure 1

Ventilation Concerns

Humidity and Odors

Humidity and odors can be annoying and a source of discomfort when present in excessive amounts. Over time, high indoor humidity can cause serious structural problems with wood rot and damage to other building materials. When odors linger or excessive condensation accumulates on windows, it is an indication that your home may not be receiving an adequate supply of fresh air.

Solutions to moisture problems are detailed in **Moisture and Home Energy Conservation**, another free publication available from DNRC. Always try the simple steps first to solve condensation problems. They are usually the lowest cost actions.

It is important to understand that homes with condensation problems do not necessarily have a ventilation problem. There are other causes for condensation besides lack of ventilation, such as inadequate insulation or poor weatherstripping. Conversely, solving a condensation problem does not imply that there is no ventilation problem.

Indoor Air Pollutants

Identifying the Problem

Our indoor environment has changed. Questions are now being raised about the possible adverse effects of lower air leakage on indoor air quality and the health of occupants. A number of factors can cause indoor air quality problems:

- Sources within the house may create high pollutant levels.
- Ventilation may be insufficient to remove the pollutants that are generated.
- Poor air circulation can result in localized areas of high pollutant concentrations.

The indoor environment can be contaminated in a variety of ways. Radon can enter the house from surrounding soil or groundwater or be emitted from certain masonry building products. DNRC offers two free publications on radon. Formaldehyde and benzopyrene are produced indoors by wood-burning appliances or given off by building materials and furnishings. Other pollutants, such as tobacco smoke and chemicals from cleaners and aerosols, are added by the occupants (Figure 2). Carbon monoxide from incomplete combustion or improperly operating combustion devices can create a serious health hazard. Some of the sources and health effects of these and other pollutants are described in Table 1.

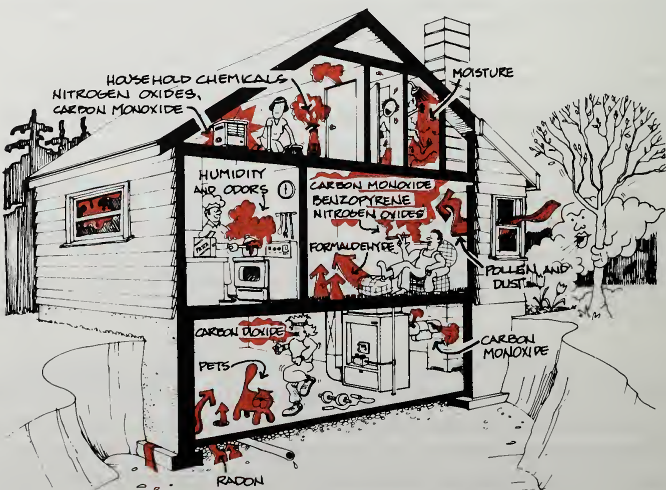


Figure 2

Table 1
Indoor Air Pollutants

POLLUTANT	POSSIBLE SOURCE	HEALTH EFFECT
Benzopyrene	Fireplaces, woodstove, tobacco smoke	Can cause coughing, headaches, nausea, and irritation to eyes, nose and throat. It is also known to cause lung cancer.
Carbon dioxide	Humans, animals, improperly operating gas appliances, kerosene heaters	High concentrations reduce the flow of blood to the brain and can cause headaches, nausea and dizziness.
Carbon monoxide	Tobacco smoke, improperly operating gas appliances, kerosene heaters, malfunctioning furnaces and fireplaces	Symptoms include headaches, mental confusion, dizziness, impaired vision and fainting on exertion. At high levels unconsciousness and death can occur.
Formaldehyde	Particleboard, plywood, carpet backing, furnishing, insulations, tobacco smoke	Can produce eye, nose and throat irritation, coughing, headaches, dizziness, nausea, vomiting and nose bleeds.
Nitrogen oxides	Kerosene heaters, woodstoves and fireplaces, malfunctioning furnaces, tobacco smoke, improperly operating gas appliances	Causes irritation of mucous membranes of upper respiratory tract. Prolonged exposure can cause lung damage.
Radon	Soil, groundwater, rock, concrete	Radioactive radon decay particles attached to dust particles can become trapped in the lungs and cause cancer.

Use this table with caution. Although these sources produce the various pollutants, high concentrations may not necessarily result. If you or your family show signs of some of the health effects listed, refer to the following section on solutions.

Long-term health effects of exposure to low levels of these pollutants are not well documented and it is difficult to establish safe concentrations. Until more research has been completed, the wise homeowner will attempt to minimize pollutant levels in the home.

Solutions

Two ways of controlling indoor air pollutants are to stop them at their source or to ventilate the home. You can limit the production of air pollutants within the home using the following methods:

- Radon infiltration can be minimized by sealing cracks in the basement, and in new homes by installing a layer of polyethylene plastic below the basement floor before pouring.

- Formaldehyde levels can be reduced by selecting chemically stable building materials and limiting the use of glues, and interior grade plywood and particleboard (which use a ureaformaldehyde resin) when building a new home or remodelling an existing one. If particleboard must be used, such as in cabinets, be sure it is well sealed to prevent the escape of gases.

- Floors of ceramic tile or hardwood finished with a natural oil can be used in place of carpet to help control formaldehyde levels.

- Nitrogen oxides and carbon monoxide can be kept at safe levels by limiting the use of unvented or improperly operating combustion appliances.

- Fireplaces and wood stoves are common sources of benzopyrene, so be sure they are installed with glass doors that fit tightly, a flue damper that seals well, and their own outdoor combustion air supply.

- Maintain and adjust all combustion appliances to ensure they are operating safely and efficiently.

- Deliberately reduce polluting activities such as tobacco smoking. This will help control levels of benzopyrene, nitrogen oxides, formaldehyde and carbon monoxide.

- Reduce your reliance on toxic cleaning products and eliminate the use of aerosols in your home.

If attempts to reduce the contaminant at the source are not sufficient to control indoor pollutant levels, it may be necessary to increase ventilation rates. Ventilation options will be discussed later.

Backdrafting

Identifying the Problem

Many devices in your home require large quantities of indoor air in order to function properly. In the winter, a home with a conventional furnace and hot water tank would use 27,000 cubic feet per day of house air for combustion and for dilution air. A large fireplace might exhaust that same volume of air in one hour when burning. Significant amounts of indoor air can also be vented outdoors by devices such as clothes dryers and bathroom and kitchen fans. This means that there are times when an entire volume of house air could be removed in less than an hour from the average home.

Have you ever considered how this tremendous volume of air is being replaced? In the past, infiltration has usually provided the combustion and replacement air to balance the quantity being exhausted outdoors. However, if there is insufficient air available, the devices that require house air begin to compete with each other. This can result in a serious problem referred to as **backdrafting**.

Suppose you have just put a load of clothes in the dryer and are sitting down to relax in front of a warm fireplace on a cold winter night. House air is being drawn up the fireplace chimney and out the dryer vent and there may not be sufficient infiltration air to replace it. This creates a lower indoor pressure relative to the outside and air will be drawn into the house through the most convenient route. As a result, the furnace chimney may become an air supply route (Figure 3). If the furnace comes on and cannot reverse this backdraft condition, combustion gases that would normally go up the chimney will escape into the house through the draft hood of the furnace or water heater.

Recent research indicates that backdrafting may be a common occurrence in many homes and a potential problem in many others.

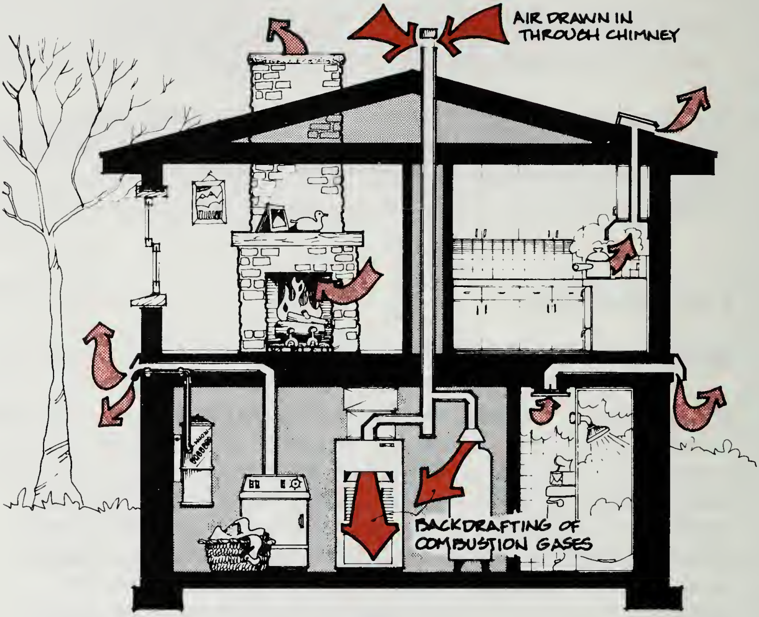


Figure 3

Here are a number of indicators that will help you determine if backdrafting is occurring in your home.

- Inspect your furnace and hot water heater for the following signs (Figure 4):
  - —Combustion odors near these appliances particularly when they have just started up.
  - —Heavy sooting, discoloration or burnt areas around the draft hoods.
  - —Condensation around the vents to the chimney. Check in cold weather when the furnace has not been running for some time.
- Problems such as high humidity and stale indoor air or odors can also be attributed to a malfunctioning chimney.
- Physical ailments caused by combustion products include headaches, nausea, coughs and stinging eyes. Serious backdrafting can cause enough combustion gases to be vented into the home to cause unconsciousness and death.

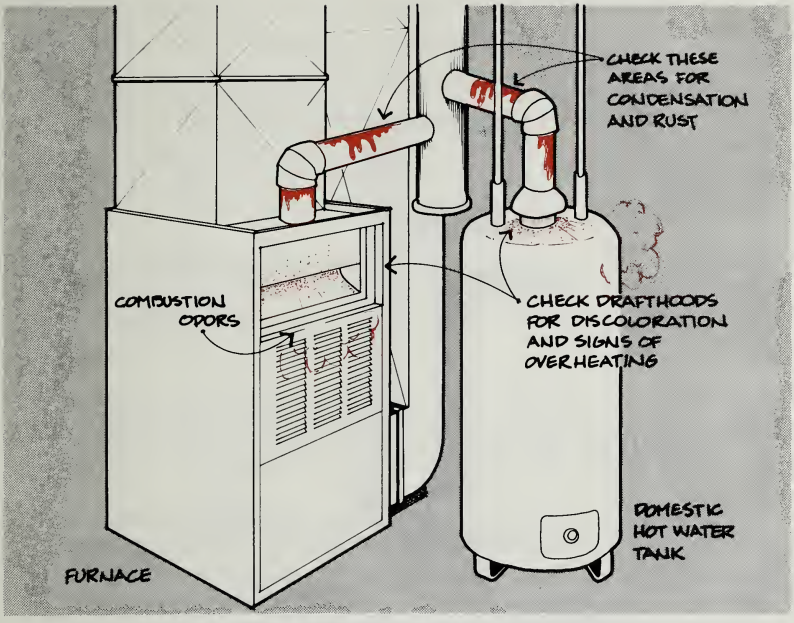
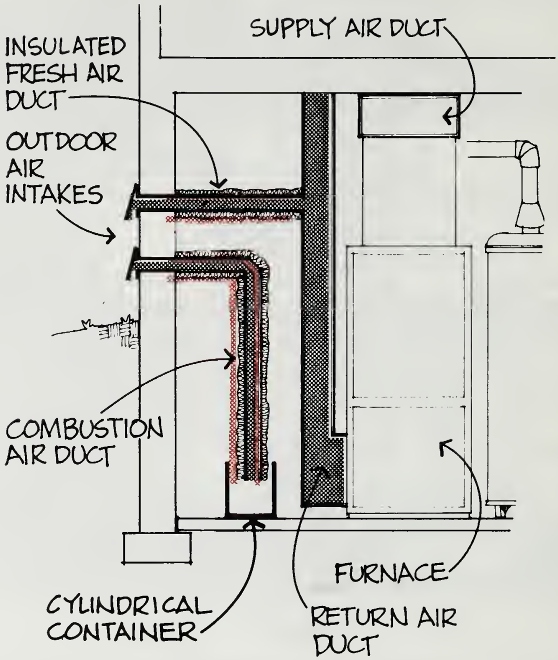


Figure 4

Solutions

Backdrafting problems should be corrected as quickly as possible because of the health hazards. A number of sources can be contacted for assistance. Your gas utility may offer an inspection service or direct you to qualified service personnel. Finally, you might contact a heating contractor qualified to service your furnace.

Qualified technicians will inspect the chimney and venting system for damage and blockage and conduct an appliance backdraft test. If your furnace or water heater is backdrafting, you must increase supplies of combustion and replacement air. One method is to install a separate insulated fresh air duct from the outside to the floor area near the furnace and hot water heater (see Figure 5 — open duct technique). American Gas Association-approved automatic dampers are available for controlling the amount of combustion air supplied. An insulated fresh air duct from the exterior to the return air plenum of a forced-air heating system is also installed to provide air for other appliances and vents.



OPEN DUCT TECHNIQUE

Figure 5

If the fireplace is backdrafting, it should be equipped with glass doors which fit tightly, and its own supply of outdoor combustion air. Since some fireplaces are not designed to be used with glass doors, consult a fireplace dealer before arranging to have any of these features installed.

Choosing a Ventilation System

For new tightly-built homes most experts recommend that the entire house have a mechanical ventilation system capable of providing one-half an air change per hour. This is the equivalent of 100 cubic feet per minute (cfm) in a 1,500 square foot house.

The system you choose should also satisfy the following performance requirements.

- **It should supply each room of the house with a continuous supply of fresh air, at a rate of about 5-10 cfm**. Higher ventilation rates are necessary for kitchens and bathrooms. A good ventilation system will be capable of providing 50 cfm to bathrooms and 100 cfm to kitchens on an intermittent basis.

- **It should be effective in distributing fresh air to every room of the house.** In homes with a forced air system, this could be accomplished by running the furnace fan continuously at a low speed.

- **It should meet minimum comfort requirements**. Cold outdoor air should not simply be dumped into the living space. It must be tempered to prevent uncomfortable drafts or cold spots.

- **It should not affect the operation of the combustion appliances**. It is not sufficient to simply exhaust stale air from the house and depend on air infiltration to supply an equal amount of fresh air. If air is drawn out of the house faster than it can be replaced, a negative indoor pressure will be created indoors and backdrafting can occur.

- **It should be controllable.** Controls may be manual (such as operable windows or adjustable dampers) or automatic (such as power switches or humidity controllers like dehumidistats).

There are a variety of systems and techniques for ventilating the home. The following sections examine each one.

Passive Systems

Passive ventilation systems operate without the use of fans. An open window is one example. Open windows, however, are not practical on cold, windy, winter days and they will not provide a constant ventilation rate. The turbine ventilator and associated ductwork is another device that provides passive ventilation, but it also cannot provide a constant ventilation rate. In addition, there is no control over the distribution of the fresh air.

Another method of passive ventilation is to bring fresh air into the home through an open fresh air duct (Figure 5), as part of the solution to backdrafting. This will be effective only if there is a significant amount of exhaust elsewhere.

Exhaust-Only Systems

An exhaust-only system uses fans to remove stale air from the house. This creates a negative pressure indoors and causes fresh outside air to be drawn into the home through infiltration or specially designed wall inlets. Kitchen and bathroom exhaust fans are simple exhaust-only ventilation systems.

Exhaust fans can be installed in high humidity areas such as the bathroom, kitchen and laundry room. It is best to install the fans on interior walls, vented through ducts down the wall cavity and exiting through the joist space (Figure 6). This method inhibits warm air leaking up the duct. Make sure the exhaust fans are powerful enough to move the air the distances required. If vents must be installed through the attic space, they should include a backdraft damper insulated and well sealed so that warm, moist air cannot leak into the attic space.

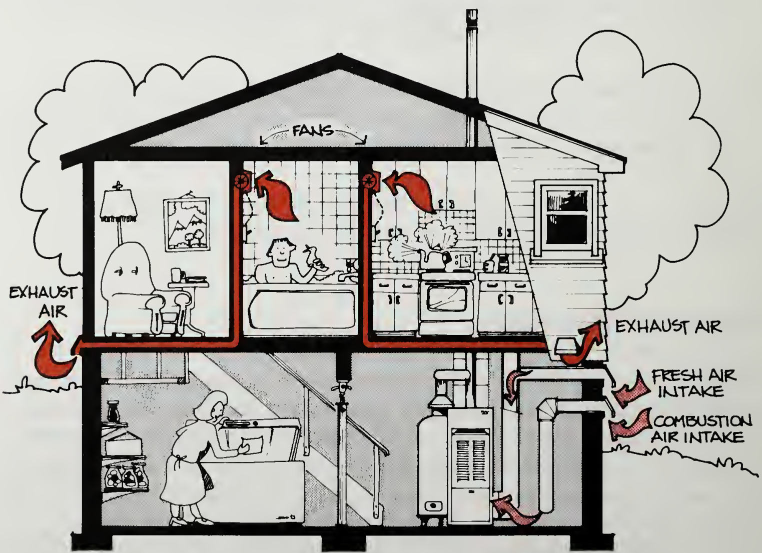


Figure 6

For continuous ventilation, a single, centrally located fan can be installed to draw exhaust air from a high moisture area such as the kitchen or bathroom. The fan can be controlled by a dehumidistat which will turn the fan on or increase its speed when humidity levels rise above a set limit.

An improvement on this is an exhaust-only ventilation system which circulates air throughout the house continually and expels humid air outside only when necessary (Figure 7). Its operation is also controlled by a dehumidistat. More elaborate control systems such as those described under heat recovery ventilators may also be used.

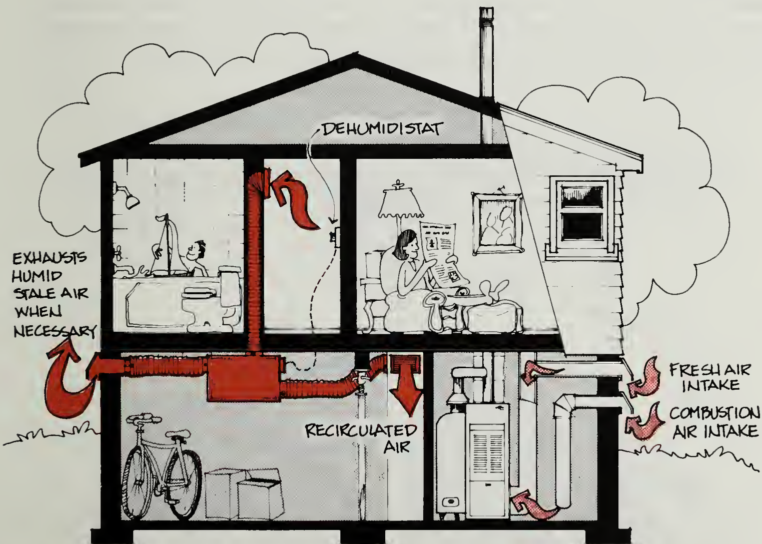


Figure 7

With any exhaust-only ventilation system, the resulting lower indoor pressure increases the potential for backdrafting. Therefore, adequate combustion and replacement air must be provided through other openings such as fresh air ducts. These systems should not be used in homes insulated with urea formaldehyde foam insulation (UFFI) since formaldehyde tends to be drawn into the house.

Heat Recovery Ventilators

How They Work

Other ventilation systems can provide good indoor air quality but they also increase energy costs as the cold air must be heated. In order to reduce heating bills, attention is being focused on the use of **heat recovery ventilators**, commonly referred to as air-to-air heat exchangers.

Figure 8 shows how a heat recovery ventilator works. A fan draws warm, humid, stale air from the house and passes it through the core of the unit. Heat from the warm air is transferred through thin sheets or pipes before the air is exhausted outside. At the same time, another fan draws in an equal amount of cool, dry, fresh air from outside and passes it through the ventilator where it picks up the heat lost from the outgoing air. This prewarmed incoming air is then distributed throughout the house.

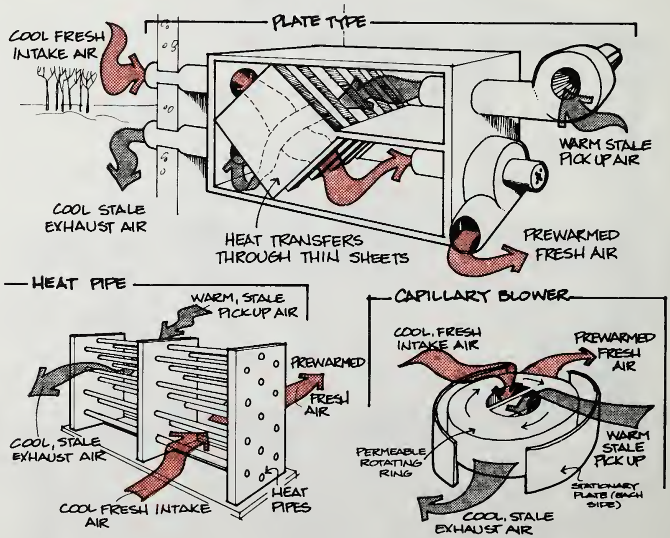


Figure 8

In order to keep outgoing and incoming air streams physically separated so that the fresh air will not be contaminated, each heat recovery ventilator contains a heat exchange core. Figure 8 also shows a variety of cores including flat plate heat exchangers, rotary wheel heat exchangers and finned tube assemblies using tubes charged with a refrigerant.

System Design

Most heat recovery ventilators use ductwork to move air throughout the house. The ducting layout and venting arrangement is critical in attaining good air mixing. Ideally the ventilator should draw stale air from all parts of the house and replace it with fresh air. In practice this ideal situation is only approximated. If your home is an "open" design with few partition walls, then air mixing will generally be good. Homes with many rooms have poorer circulation and may require extra ductwork to achieve adequate air movement.

In homes with forced air systems, the furnace fan and ducts are commonly used to distribute fresh air throughout the house (Figure 9). Stale air pickup ducts, separate from the heating system, draw air into the ventilator from the kitchen, utility rooms and bathrooms, which most tend to produce moisture, pollutants and odors. The kitchen stale air pickup is kept separate from the range hood exhaust fan to reduce the problem of cooking grease and smoke fouling the heat exchanger core.

Venting the clothes dryer exhaust directly into the ventilator is not recommended by most manufacturers.

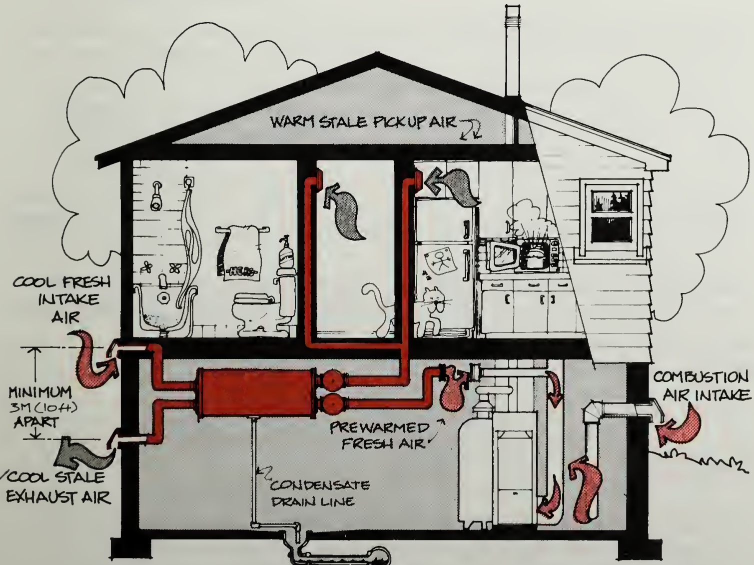


Figure 9

The cold air intake line running from outside to the ventilator and the stale air exhaust line from the ventilator to outside are run through the floor header joist to exterior hoods, much like dryer vents. The ventilator is placed close to an outside wall when possible to keep these two ducts short. This ductwork will be cold and should be insulated and wrapped in a vapor barrier to prevent condensation and conduction of heat out of the house. Outside it is wise to separate the exhaust port from the intake port by at least 10 ft. This prevents cross-contamination of the fresh air inlet by the exhaust air. The vents must be placed a minimum of 18 inches above snow level to prevent blockage.

In order to distribute the prewarmed air throughout the house using a forced-air heating system, the supply air duct from the ventilator empties into the house 4 to 12 inches from a return air grille. There must not be a direct connection between the ventilator supply and the forced-air system. If the ventilator is connected directly, changes in the speed of the furnace fan can cause an imbalance between the supply and exhaust air flow through the ventilator. If the fresh air supply pick-up register is located in the area of the furnace, be sure it is located outside a furnace room. In order for the fresh air to be distributed, the furnace fan must run whenever the ventilator is on. This is best accomplished by running the furnace continually on low speed.

In houses with baseboard or wood heating systems, additional ductwork must be installed to distribute the prewarmed fresh air — much like a small forced air system. Fresh air is supplied to the living rooms and bedrooms while the exhaust air is drawn from the kitchen, bathroom and laundry areas. Supply lines are best located in non-sitting areas or above baseboard heaters since the incoming air will be cool. They may also be placed near the ceiling where the cool air will mix with warm air at the ceiling.

Combustion and replacement air must be supplied separately. The heat recovery ventilator only replaces the stale air it removes from the house and will not provide for any other air requirements.

Controls

Humidity measurement is presently the most practical method of controlling the operation of the heat recovery ventilator. It would be more effective to provide control on the basis of both humidity and certain pollutants, but inexpensive, effective air

pollutant analysers are not yet commercially available. An example of how a control system could be connected is shown in Figure 10.

The following guidelines should be considered when selecting controls:

- Install timer switches in each bathroom and in the kitchen. When the switches are turned on, the ventilator fans are boosted to high speed for the duration set on the timer. This is an effective method of providing spot ventilation. Manual wall switches will also work but must be conscientiously shut off once high speed ventilation is no longer necessary.

- Install a dehumidistat in a central location away from any ventilator supply grilles. Choose an area of average humidity and, if possible, locate it near the thermostat. The dehumidistat operates the ventilator fans at normal speed when the humidity is below a set point, say 40 per cent, but automatically boosts the fans to high speed when the humidity climbs above this level. Once the humidity falls the fan reverts to normal operating speed.

- Be sure the ventilator has a variable speed control to regulate the normal fan operating speed. In this way, the continuous low speed setting of the unit can easily be adjusted to suit the occupant's lifestyle.

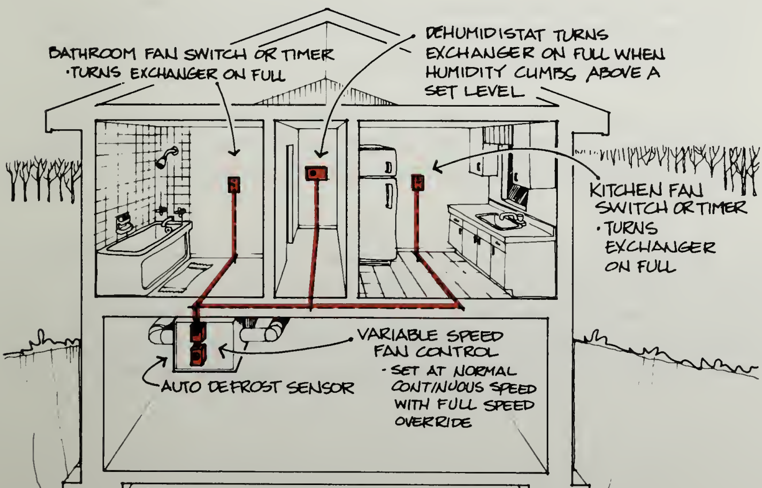


Figure 10

Selection and Installation Guidelines

There are a number of heat recovery ventilators available but not all of them are capable of providing effective and efficient ventilation. However, ventilator deficiencies are being identified, and manufacturers are improving their equipment design.

When choosing a heat recovery ventilator you should examine the following:

- The ventilator should have the capacity to exchange one-half the total volume of air in your house every hour. For an average house this is equivalent to 150 cfm. The actual ventilator capacity will need to be greater than this to overcome the resistance of the ductwork.

- It should have a variable speed control or a dehumidistat to adjust operation to the needs of the house.

- Look for a defrost mechanism to melt any frost or ice that may build up inside the heat exchanger core during cold weather. Preferably the heat exchanger should not shut off fans during defrosting.

- It should have easy access for cleaning the core which accumulates dust and dirt. Regular cleaning is necessary to maintain heat exchange efficiency.

- When installed the ductwork must have filters to clean the air. The filters are placed on the incoming fresh air and the stale air pickup lines. They must be cleaned regularly like the furnace filter.

The choice of an installer for your heat recovery ventilator must also be given careful consideration. Many of the problems associated with these devices can be prevented if the unit is installed properly. Check that your installer is trained and experienced in installing heat recovery ventilation systems.

Summary

- Become familiar with the ventilation requirements of your house.

- Determine if you have problems caused by inadequate ventilation. Check for:
  - Prolonged condensation on your windows in winter;
  - Symptoms of health problems resulting from indoor pollutants;
  - Signs of backdrafting.

- Decide on the proper solution:
  - Turn the humidifier off;
  - Install a fan in the kitchen;
  - Eliminate pollutant sources;
  - Install a combustion air line to the furnace;
  - If necessary, choose an appropriate ventilation system.

Providing adequate ventilation makes sense. You will be able to control your indoor environment and maintain a fresh, healthy atmosphere.

How To Save Energy